the rarest. They also ate venison of the stag (*Cervus elaphus*). Their place in the archæological scale of culture is fixed by the few and simple forms of bronze articles in the barrows, the simple wedge-shaped axe, and the short broad dagger, in association with various articles of stone, coupled with the absence of the higher bronze types, such as the sword. They belong to the early bronze age. The absence of the sword is also noticed in the tumuli of France, referred by Mr. Chantre to the same horizon. At this time the knowledge of bronze was gradually finding its way northwards from the Mediterranean centres, and the simpler forms preceded the more complex and elaborate.

Nor are we left in doubt as to the ethnical relations of these ancient Yorkshiremen. Prof. Rolleston's elaborate examination of the crania and skeletons reveals the fact that the two types—the small long-headed or "Iberian," and the tall robust round heads, or "Celtic," which have been traced by Thurman, Huxley, Busk, and myself, from Scotland to the Mediterranean, and from the Rhine to the Pillars of Hercules, occur in the round barrows side by side in intimate association. The former of these, "the Silurian" of Prof. Rolleston, is considered in this work as the older of the two. According to Dr. Thurman it was dormant in Britain in the Neolithic age, at the close of which it was invaded by "the Celtic" or "the Cimbric" of Prof. Rolleston. The truth of this view is confirmed by the fact that the dead of these two races rest peacefully together in the round barrows of the wolds referable to the early bronze age. In concluding this review it remains merely to say that this valuable work fills a void in the archæological record of Great Britain, and that it contains a larger mass of accurately observed facts than any book hitherto published relating to the Bronze Age in this country.

W. BOYD DAWKINS

THE ECLIPSE OF THE SUN

THE following letter appears in the *Daily News* of Tuesday, from its Special Correspondent, dated Manitou, Foot of Pike's Peak, Colorado, August 2 :—

Since the eclipse I have had no easy time of it. To gain accurate information concerning the work done along the long north and south line, on which, as your readers already know, the stations were located, it was necessary to return over the crest of the Rocky Mountains at Sherman (8,200 feet) down to Cheyenne, and then go as far south, by the Colorado Central line, as Colorado springs, passing Denver on the way. Manitou, whence this letter is written, is about six miles from the latter place on the old and famous Ute trail, a road much improved in these later days for the needs of the enormous traffic connected with the mines at Leadville. The place itself is lovely—so lovely, indeed, that although it is over 2,000 miles from the eastern seaboard, the hotels and baths (iron and alkaline) formed but a nucleus for a large encampment, tents dotting the slopes in all directions. The newly-published geological map of this region with which Prof. Hayden, with his wonted generosity and forethought, had supplied some of the astronomers, enabled them to revel with more or less success in the wonders of the famous "Garden of the Gods," and Glen Eyrie, where the rocks put on everything they can in the way of uncommon arrangement and colour. Vertical beds of limestone and sandstone 300 feet high, and not many yards thick, even at the base—each spire excelling the other in some glorious colour, including all those we see in an English sunset—is a sight never to be forgotten, even if Pike's Peak, with its patches of snow, were not seen through such gigantic and weird portals.

Here, then, we met the Pike's Peak and the Las Animas parties, all rejoicing over their success. Two of the former—General Myer, the creator and chief of the wonderful meteorological signal surface, and Prof. Cleveland Abbe—have suffered somewhat from their sudden transference from the plains to a height of above 14,000 feet. The latter, indeed, had to be transferred on a litter, by the General's order, to a station at mid-height before the eclipse. But the journey to Manitou does not exhaust my wanderings. Much was expected from Prof. Holden's party at Central City, easily reached from Golden City by one of the most wonderful railways in the world. To Central City, therefore, I went up to a point called Black Hawk. The railroad is filched from the bed of a stream at the bottom of a true cañon. Here rail and river together are not fifteen yards broad, and precipitous cliffs 1,000 feet high shut out the light. Here, again, the cliffs recede, the river bed widens, and miners—American and Chinese—are engaged in extracting the precious gold from the turbid water and its bed, some of the miners making in this way 1,500 dollars a week. From Black Hawk to Central City there is no possible approach except up the side of a steep hill. The railway accepts the condition, and zigzags up—now engine, now cars, foremost—till the nest of stamping mills and smelting furnaces at Black Hawk looks like a speck below.

The party at Central City had been as fortunate as the rest in the matter of weather, and their station, on the top of Teller's Hotel, in the middle of this strange mountain community, had proved a very convenient one. After my last letter to you, I became acquainted with the fact that Mr. Burnham, so well known for his work on double stars, and whose eye seems to be keen as was formerly Dawes's among us, was going to observe the eclipse on behalf of the *Chicago Times*—a piece of newspaper enterprise worthy of imitation. I tried to find him when I passed through Denver to Prof. Young's camp, but was unsuccessful, though I was fortunate enough to see Prof. Young himself, whose party was second to none either in *personnel* or in their means at the disposal for securing good results.

My telegram to you, immediately after the eclipse, was necessarily based upon the most meagre materials, and laid emphasis upon those parts of the combined attack which were most strongly represented at the northern stations. Still, now that the complete information is before me, I have very little to alter, so singularly and exceptionally do the observations support each other in the main ; and I say in the main, because on some points there is enough disaccord to make the astronomers already look forward to the next eclipse. Without going too much into detail I will go over the ground in the light obtained by personal communication with the chiefs of the different parties, with the single exception of Prof. Hall, who is a most skilful and competent observer, and to whose opinion, as the discoverer of the satellites of Mars, the greatest weight is to be attached. The corona was much less brilliant than usual. Those who have observed the greatest number of eclipses are strongest on this point. The contrast, perhaps, is most striking between this eclipse and that of 1871 observed in India. Now that this fact is recognised, the naturalness of it is apparent to everybody. We know that the sun's activity and the various meteorological and magnetical conditions on our own earth which depend upon or are connected with it wax and wane every eleven years or so. This is termed the sun-spot period. Thus the sun was very active in 1871, and it will be again very active in 1882. It is very sluggish now, and it will be sluggish again in 1889. In 1871 we had many spots, many prominences, many magnetic storms and auroræ, heavy rainfall, and, let me add, no famines to speak of. Associated with these we had a large corona. This year there are no spots, the prominences are rare, the magnets were never so quiet, there are no auroræ, and we are passing through a famine period. Associated with these we had a small corona. Hence it is that the astronomers agree that this year another connecting link has been added to the chain which binds together the solar changes.

On another point mentioned in my telegram the evidence is overwhelming. Since the use of the spectroscope in this branch of inquiry the spectrum of the corona has been observed to be a mixed one—that is, bright lines as well as a continuous spectrum have been traced in it. In 1869 and 1871 these lines were very bright to the eye—much brighter than the continuous spectrum, while in 1875, when the spectrum was photographed for the first time, the record showed the lines to be much brighter than the continous spectrum. Now, as it generally happens that when in our laboratories we study gaseous spectra there is a faint continuous spectrum accompanying the lines, it was thought that the spectrum of the solar corona might have a gaseous origin exclusively. This year's observations have quite dispelled this idea, for the two elements of the corona spectrum, to which attention has been drawn, instead of varying directly, vary inversely. The continuous spectrum has been seen and photographed by itself, without any bright lines. Now for the interpretation of this hieroglyphic language. The gases which were high up in the sun's atmosphere at the last epoch of maximum sun-spots (1871), have almost entirely retreated to a lower level; as these gases are to a large extent carriers of heat from the interior to the exterior of the sun, the exterior is cooler in their absence, and indeed cool enough to allow it to hold in suspension a larger percentage of solid and liquid particles to which the continuous spectrum is due. A natural suggestion touching these particles is that they consist of meteoritic matter, and all the phenomena to which attention has been drawn can be explained by supposing that these meteorites surround the sun, and that at the minimum sun-spot period they can exist lower down in consequence of the reduced temperature of the sun's atmosphere at that time. If this suggestion, which is the one in favour out here, be endorsed we have a partial cause of reduced solar radiation at that time. I cannot quit this part of the subject without referring to the wealth of astronomical resources which have been brought to bear upon it. Paper astronomers have been now for a long time, I doubt not, very lucratively employed in proving that it was impossible to do exactly what has been done. Dr. Draper, who ranks deservedly high among solar observers, bears off the palm by the strength of his attack. He used a camera of six inches aperture and of only twenty-one inches focal length, and, by means of a Rutherfurd grating two inches square, obtained a photograph of the corona and two of its spectra with the same instrument. The plates were exposed during the whole of totality, and it is encouraging for future work to know that much less exposure would have sufficed to secure the precious records, although the continuous spectrum recorded is the most difficult to obtain. Prof. Harkness used an instrument of nearly equal power, though of slightly different arrangement. The smallest instruments employed—ordinary portrait cameras with a grating in front—also gave the same result, though, of course, on a much smaller scale.

Next comes the endorsement of the fact that the coronal light is due partly to solar light—that all the light it sends to us is not its own. Prof. Barker, with Dr. Draper's party at Rawlings, though he saw no bright lines, saw dark ones in abundance; and Prof. Morton got distinct traces of radial polarisation, thereby endorsing the result obtained in 1871. The object of these observations by the polariscope is to determine whether and in what plane light is reflected; and for the light to be reflected to us by particles in the sun's atmosphere we must imagine our eye, the centre of the sun, and the particle to lie in one plane. If, further, we imagine an infinite series of particles surrounding the sun, we shall have an infinite series of these planes, and each radius of the sun will lie in one of them. I have been particular in stating this, because Prof. Hastings, a great authority in optical matters, declares that the reflection takes place at right angles to these radial planes; in other words, he declares that the polarisation is tangential and not radial. As has been well remarked, this result is easily explained by supposing ice crystals to be present in the sun's atmosphere, and no other solution lies on the surface. I believe no one is more astonished than Prof. Hastings at his observation; and here again we see the necessity of relaxing no efforts and letting slip no opportunity of garnering the observations with which eclipses alone supply us.

Finally, as to the construction of the corona. Numberless records of this, both visual and photographic, have been secured, and as usual, though there is almost perfect agreement as to the structure of the lower portion, the rays and streamers have been very variously observed. The upper and lower portions of the sun were graced by the most exquisite tracery, bending over right and left like plumes of ostrich feathers, the intervals between them being of a delicate blue. Near the solar equator the structure was not so obvious. Still, it was there, for Prof. Bass saw it come out *and pulsate* after he had fixed his eye on one portion for two minutes. The structure was distinctly less filamentous than in 1871. With regard to the streamers there appears to have been two sets—one along the ecliptic, giving rise to the appearance of a wind vane seen by one set of observers; another, at right angles to this, seen by another set. Neither of these systems of streamers was visible in a telescope, though the base of the ecliptical ones appears on the photographs. On this point the greatest weight must be given to the observers on Pike's Peak, 14,147 feet high. Most fortunately the weather there as elsewhere was superb, and the corona was seen as it was never seen before. The clearness of the sky in this region when the weather is good is simply wonderful. The Milky Way seems to have deep holes in it, and the individual stars shine out. Even at Rawlings Prof. Watson could see the satellites of Jupiter with the naked eye. At Pike's Peak General Myer saw the corona for fully five minutes after totality was over, while in India, in 1871, the much brighter corona was seen at sea-level for only three minutes after the eclipse was over. Prof. Cleveland Abbe, who, as already stated, observed below the Peak, saw the ecliptic streamers extending to a distance of twelve solar diameters, while he saw nothing of the north and south ones, pretty conclusive evidence in favour of their subjectivity, and from their appearance he has little doubt of their being meteor streams. Prof. Newcomb saw the ecliptic streamers almost equally well at Separation by the help of a novel contrivance. He had a disc erected on a high pole at some distance from his telescope so that he could momentarily cover the dark moon and corona and observe the external phenomena with the naked eye. In this way he saw the streamers extending nearly as far as Prof. Abbe did. Still he explains them differently. He considers that they indicate the true zodiacal light. No doubt there are difficulties surrounding both suggestions, and here again we see the need for future thought and work. The regions in which the various parties were located enabled many of the connected phenomena to be observed as they had never been before. From Pike's Peak, with its horizon of 150 miles on all sides, the shadow of the moon sweeping rapidly through the air was a very tangible thing and seemed to be solid enough to sweep all before it. It was noticed on the air and on the very buttresses of the Peak that the boundary of the shadow was strongly coloured in the prismatic order. The wide extent of Alcali Plains round Separation and Preston—plains broken by nothing save the wonderful avenue of telegraph poles along the railway, and the solitary water tank and telegraph operator's house, enabled these and the associated phenomena to be seen well there also, and there were just sufficient clouds above the eastern horizon to bring out into strong relief the retreat of the shadow through the air, while during the eclipse the leaden light on the desolate plains gave rise to an intense feeling of loneliness and weirdness. The daring genius of Edison has left its mark on this eclipse. So soon as he had completed his tasimeter he saw its applicability to eclipse work in determining the presence of heat waves in the radiation from the corona. I had the rare privilege of seeing the great inventor at work gradually increasing the sensitiveness of his wonderful instrument with the most consummate knowledge of principles and contempt for elaboration, until at length during the eclipse he was rewarded by seeing the speck of light on the attached Thomson galvanometer give a decided swing from its zero on the dark moon when the image of the corona was brought on the fine slit in the plate which shielded the tasimeter from its surroundings. The instrument was too new to succeed in other hands, even those of Prof. Young; but he was not to be beaten. Driven from one instrument he took up another—the thermo-electric pile—and was rewarded by finding a heat line in the ultra-red. This opens out another new line of work in future eclipses; and so science advances. Rumour here says that one distinguished astronomer remained away because he considered eclipses "played out." What a lesson he has learned ere this touching the need of that receptivity to which I referred in my former letter!

Mindful of your space I must here conclude my statement of the more salient solar phenomena observed, the detailed discussion of which will occupy the astronomical world for some time to come. I shall have been very unfortunate and unworthy of my post if I have not succeeded in convincing your readers that several important advances have been made, and that the work done on the eclipse of 1878 will rank high in astronomical records. I have not yet, however, quite finished the story I have to tell. Students of solar physics may congratulate themselves that the gravitational astronomers will in the future insist upon having their finger in the eclipse pie. In my telegram I was enabled to announce the position of the body observed by Prof. Watson near the sun. Since the telegram was dispatched the matter has been seriously discussed by Prof. Holden and others, and little doubt remains that a new major planet has been discovered, if, indeed, Vulcan has not been refound. Prof. Watson's work has been acknowledged on all hands to be a veritable *tour de force*. The Naval Observatory instructions contained a map of all stars near the sun down to the seventh magnitude. Prof. Watson determined to review all these, and provided his equatorial with paper circles on which to mark the difference of right ascension and declination between any body not marked on the chart and the sun. After the eclipse, and before the instrument was dismounted, Prof. Newcomb and Mr. Lockyer saw the precious record *in situ*. It was here at Manitou that Prof. Watson again reviewed his work, and despatched a telegram to the Smithsonian Institution corroborating the one I had previously sent to you.

The English observers are full of appreciation of the reception they have met with from their American *confrères*. Prof. Thorpe and Dr. Schuster were the guests of Prof. Hall's party at Las Animas. Mr. Lockyer, invited by General Myer to Pike's Peak, by Dr. Draper to Rawlings, Prof. Newcomb to Separation, and Prof. Wright to Las Animas, decided for Rawlings, where Dr. Draper placed all the resources of his observatory at his disposal. A thing unknown in England—that is, a travelling railway photographic car—being, however, placed at the disposal of the astronomers by its proprietor, Mr. Silvis, it was decided at the last moment to establish another station, and on the morning of the eclipse Prof. Watson and Mr. Lockyer proceeded to Separation, a station on the Union Pacific Railway, between the eclipse camps there and at Preston.

The *Times* correspondent, writing from Pueblo, South Colorado, July 31, states that Dr. Schuster brought out with him a couple of fluorescent eye-pieces, with a view of re-determining the position of the lines he observed in 1875; but a too-confiding faith in the tender mercies of the baggage-men in charge of the instruments led to the utter destruction of one of the eye-pieces, while the other was so injured that it was impossible to get it into order in time for the eclipse. Indeed, nearly all the instruments, in spite of most careful packing, suffered more or less damage, either during their canter—for such it can only be called—along the Western railroads, or at the hands of the "baggage-smashers" who took charge of them at the depôts. The baggage arrangements of American railroads are doubtless perfect in theory; but the practical application of them is simply ruinous to scientific apparatus.

The newspapers are filled with allusions to the phenomenon; its effect on animals, on the colours of objects, and on their visibility, was noted everywhere. The darkness was far from being so great as was anticipated; the decrease of temperature was, however, very considerable. At La Junta it fell from 96° to 80°; at the time of last contact it had again risen to 93°. In Pueblo the fall was as great as 23½°—*i.e.*, from 103° to 79·5°.

The following interesting and amusing account of the eclipse observations of Prof. Lewis Swift, by a reporter of the *Rochester Democrat*, appears in the *New York Tribune*.

Prof. Lewis Swift returned from Denver, Col., Saturday evening, bringing splendid trophies of his skill as a searcher of the heavens. That his discovery was not duly reported by the Associated Press is chiefly owing to Prof. Swift's modesty in heralding the results of his labours and his desire to carefully determine the significance of his observations before making public announcement. Yesterday afternoon we visited Prof. Swift at his pleasant home in Ambrose Street, and learnt from him the story of his visit to Denver and observations of the total eclipse. Prof. Swift said:—"Up to the time of the eclipse the prospects for a clear day were very poor. The nights were clear, but it was cloudy, and rainy every afternoon. Sunday afternoon there was a clearing storm, with hail and drenching rain. Up to Sunday afternoon an unprecedented amount of rain had fallen in the region. On Monday morning there was not a cloud in the sky, and all predicted a clear day, and we had it. The final preparations were made as rapidly as possible. A. C. Thomas had arrived at the eleventh hour from Chicago with a telescope and spectroscope attachment. Prof. Hough had brought a small telescope with fine lines stretched across the object-glass, and a micrometer eyepiece, for the purpose of measuring the corona. I had secured from the Mayor the services of a police-officer to keep the grounds about the instruments clear from spectators. According to Washington predictions the eclipse was to commence at 4h. 7m. 50·4s. According to Prof. Colbert's calculations it would begin at 4h. 10m. 50s., Washington time—a difference of three minutes. Prof. Colbert's prediction, was proved to be very nearly correct. About half an hour before the eclipse was to begin our party took their positions. I was about twenty feet to the south of Prof. Hough, who was in a group consisting of himself, Prof. Colbert, and Prof. Easterday, who used the telescope for observing the corona. To the west was a class of fifteen young ladies from Denver, instructed by Prof. Colbert to sketch the corona. South-east of my position Mr. Thomas was stationed.

"When arranging my instrument I made the post very low, exciting much comment by my companions. I told them I intended to lie on the ground during the observations, this being a position I had found the easiest in my experience of twenty years' comet-seeking. I spread a carpet on the earth and had a great advantage over the other members of the party, who were obliged to assume constrained positions, which tended to unsteadiness of vision. Seated by me was Daniel Drummond, with an accurate time-piece, set by the chronometer a few minutes before the first contact. E. D. Smith, an old acquaintance, whom I met in Denver, recorded the time of each event as I called it. Mr. Drummond is an experienced engineer, and counted the seconds with great accuracy.

"As I arranged my telescope for the first event the wind was blowing in fitful gusts from the south-east, shaking our instruments. To prevent my instrument from swaying I tied a long stick to it, about a foot above the eyepiece, the other end being braced against the ground and free to move only in one direction. This was a blunder to which I owe the discovery of a stranger, which I am inclined to think is Vulcan. As the sun moved the eye end of the telescope moved to the east. The stick would not allow any backward movement, and when I attempted to observe the sky to the east of the sun I could not. This confined my area of vision to a small distance west of the sun. But to return to the observation. My observation of the first contact was four seconds later than the observation of Prof. Colbert. The following is my record of events by Washington time:—

	h.	m.	s.
First contact	4	11	18
Bailey's beads	5	20	22
Beginning of totality	5	20	38
Corona first seen	5	23	17
End of totality	5	23	26
End of eclipse	6	26	35

"The watch was one second slow of the chronometer at the first contact, two seconds at the end of totality, and four seconds at the end of the eclipse. Before the eclipse began I had made up my mind to observe the general phenomena, the corona, protuberances, and Bailey's beads for about half a minute at the beginning of totality. I designed a minute and a half for a search for Vulcan, and the remainder, some forty odd seconds, to observe the phenomena at the end of totality.

"About one minute after totality two stars caught my eye about three degrees, by estimation, south-west of the sun. I saw them twice, and attempted a third observation, but a small cloud obscured the locality. The stars were both of the fifth magnitude, and but one is on the chart of the heavens. This star I recognised as Theta in Cancer. The two stars were about eight minutes apart. There is no such configuration of stars in the constellation of Cancer. I have no doubt that the unknown star is an infra-Mercurial planet, and am also inclined to believe that there may be more than one such planet. In 1859 the French astronomer Lescarbault claimed that he had seen an intra-Mercurial planet crossing the sun's disc. He related his discovery to Leverrier, who became a firm believer in the existence of such a planet. The perturbations of Mercury's orbit demand such a planet as Leverrier named Vulcan. The star I saw may have been the same that was seen by Prof. Watson, who was located at Rawlings, Wy. T.

"I possessed a comet eye-piece of very flat and large field and distinct to the very edge. It was made in this city, and to it and my blunder in failing to untie my instrument I owe my success. Prof. Colbert, of our party, also searched for Vulcan, but his field was not large. I saw but two protuberances, and those just at the end of totality. The advancing moon uncovered them. I had a view for at least two seconds of the sun's chromosphere at the same time. The chromosphere, by my measurement, is 2,000 miles in thickness. It is a layer of red-hot hydrogen surrounding the sun. The protuberances are projected from it.

"The corona was unusually extensive. It had never been seen so far extended. The greatest prolongation was in the direction of the moon's path across the sun, and as drawn by some of the parties extended on each side of the sun to a distance of more than three million miles. The pencils of light were radial mostly, though some of them were curved. I came away so quickly from Denver that I did not learn of the success of the other parties. In comparing notes with our party, Prof. Hough agreed with me in the measurement of the chromosphere. This measurement is made by calculating the time it takes the moon to pass over it. I learned of Prof. Watson's discovery the day after the eclipse. I have not seen him since he made the observation."

OUR ASTRONOMICAL COLUMN

WATSON'S SUSPECTED PLANET.—At the instance of M. Mouchez, the director of the Bureau des Calculs of the Observatory at Paris, M. Gaillot, who so long assisted Leverrier in the formation of his planetary tables, has examined how far the position of the object seen by Prof. Watson will accord with the more probable of the orbits which Leverrier inferred for a hypothetical planet, from the observations of suspicious spots in transit over the sun's disc. It may be remembered that their discussion led to a general formula, which was thus expressed by Leverrier; ν being the heliocentric longitude of the planet, k an indeterminate which might have values positive or negative, but necessarily whole numbers, and j the number of days reckoned from the beginning of the year 1750:—

$$\nu = 139^\circ{\cdot}94 + 214^\circ{\cdot}18\,k + (10^\circ{\cdot}901252 - 1^\circ{\cdot}972472\,k)\,j$$
$$+ (-5^\circ{\cdot}3 + 5^\circ{\cdot}5\,k) \cos.\ \nu.$$

M. Gaillot has found that, of the four possible orbits retained by Leverrier, corresponding to $k = -2, -1, 0,$ and $+1$, respectively, the first agrees the closest with the observation. With this value of k the diurnal motion is 14°·8462, the semi-axis major 0·164, and the period of revolution 24·25 days—less than the period of the sun's rotation. When the question of eccentricity is introduced, it is remarked that in the preferable orbit it is already very considerable, and comparable with that of the orbit of Mercury, and it is easy to demonstrate, to use M. Gaillot's words, "qu'il peut y avoir identité absolue entre la position observée et la position prévue." In fact, he finds that the agreement will be perfect if the eccentricity is assumed 0·14, and the longitude of the perihelion 74°. With regard to the inclination of the orbit to the ecliptic, M. Gaillot, from further consideration, supposes it may not exceed 7°. He notes that the most serious objection which opposes itself to the identification of the object observed, with a planet moving in the orbit indicated by Leverrier's formula, is that we should see but a very small part of the disc illuminated, and without denying that there is reason in this objection, M. Gaillot adds that Prof. Watson describes "as being of the fourth magnitude, a star the diameter of which may be comparable with that of Mercury, and which, in superior conjunction, may appear of the first magnitude." He further remarks that while it is not possible to decide with certainty upon the identity of